EXECUTIVE SUMMARY

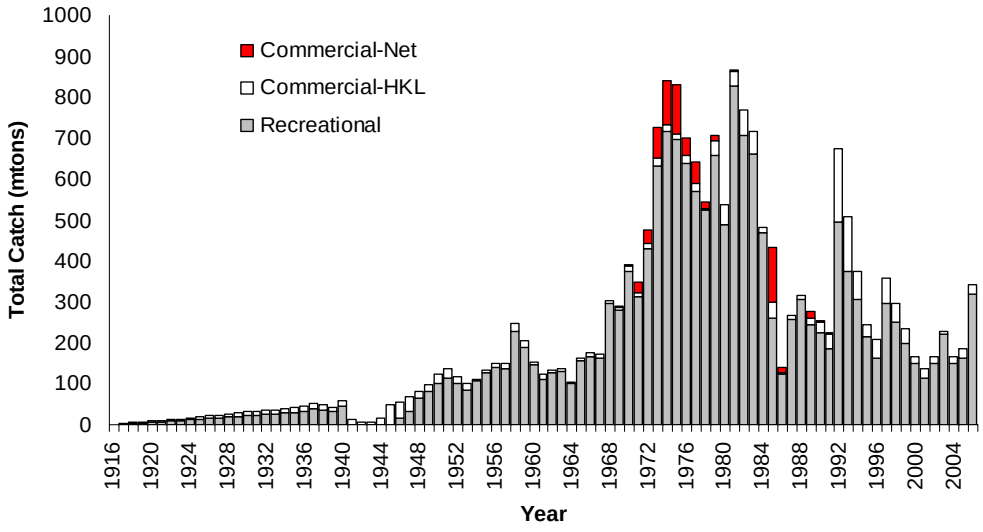
Stock

This is the first assessment of blue rockfish (*Sebastes mystinus*) on the West coast of the US. This assessment determines the status of the California stock from the Oregon border to Point Conception where blue rockfish are most commonly found, using data through 2006. This assessment treats these fish as a single stock. Blue rockfish are also harvested in Oregon and Washington, but black rockfish are more sought after in those waters. In southern California waters, a perceived decline in the relative abundance of blue rockfish may be related to environmental conditions, particularly declines in kelp cover observed in surveys throughout the 1990s.

The variability in growth over time and between areas along the coast of California were evident while assessing this stock, but the lack of sufficient data did not allow for the complex modeling needed to appropriately assess blue rockfish. Genetic evidence has also suggested two species of blue rockfish in California, so this status report is considered an assessment of a blue rockfish "complex" instead of a single species.

Catches

Blue rockfish are the primary recreational (CPFV/private) caught species in California and is also important in the commercial fishery (mainly hook and line), although landings from the commercial fishery are minor compared to the recreational catch. Due to the lack of historical reporting of blue rockfish catch, estimates back to 1916 rely primarily on a proportion of total rockfish prior to 1969 in the commercial fishery (non-trawl) and prior to 1980 in the recreational fishery. Trawl landings in the commercial fishery were removed from total rockfish catches since documented trawl studies did not report blue rockfish being landed in this gear. The catch history of blue rockfish is highly uncertain, especially in the earlier years.



Recent landings (mt) of blue rockfish in California, north of Point Conception.

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Recreational	296.1	249.4	198.6	150.7	115.6	148.8	219.9	149.9	162.9	319.6
Commercial-HKL	63.7	47.7	35.7	15.6	19.7	18.5	9.2	14.8	21.7	21.9
Commercial-Net	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	359.7	297.1	234.4	166.3	135.3	167.4	229.1	164.6	184.6	341.4

Data and Assessment

This first assessment for blue rockfish used the Stock Synthesis 2 (version 2.00g) integrated length-age structured model. The model includes estimated historical catches dating back to 1916 for each fishery (recreational, commercial hook and line and setnet), length-frequency data from each fishery and conditional age-at-length frequency data from the early 1980s from the recreational CPFV fishery. Two recreational CPFV CPUE indices (RecFIN and CDFG onboard observer program) were used as abundance indices, with the RecFIN CPUE index being split into two time periods (1980-1999 and 2000-2006) to allow for potential changes in catchability due to the bag limit change (from 15 to 10) in the year 2000. Lastly, a coastwide pre-recruitment midwater trawl survey (NWFSC/SWFSC/PWCC) provided a source of recruitment strength information for the years 2001-2006.

In this assessment, variation in growth over time and space were evident, however the lack of data did not allow the appropriate modeling needed to accurately assess this stock. Recent genetic studies have also shown there are two species of blue rockfish, which adds additional uncertainty to the outcome. Most of the catch was represented by females (70-80%), which suggests either males have a higher natural mortality (M) or they are less selected in the fisheries. Even though there are various states of nature needed to capture the uncertainty in this assessment, the proposed states of nature were based on varying M for females and males with different streams of catch histories. Probabilities were not assigned to the states of nature; however, the STAT strongly believes and provides supporting evidence that the low and BASE catch stream scenarios, producing the BASE and high M bracket, are most likely.

Unresolved problems and major uncertainties

Recent genetic studies suggest that blue rockfish is two closely-related species that intermix in the area covered by the assessment. Knowing the differences (if any) in behavior, spatial distributions, and life histories between the two species may help explain and better capture the uncertainties in this assessment.

The variability in growth over time and space is another essential element that was not properly modeled in this assessment. The models estimated growth curve appeared to be an “average” of the 1980s growth curve and the 2000s growth curve that were explored. There was not enough recent data to support the use of time-varying growth for a base model, even though there was an attempt to do so.

Natural mortality is highly uncertain and cannot be reliably estimated. The scarcity of males in the landings could be either due to higher male natural mortality or lower fishery selectivity for males.

Historical catches of blue rockfish are highly uncertain, and in some cases are based on an extrapolation from a single year of sampling or reporting. Using a proportion of total rockfish to reconstruct the historical catches is very worrisome. Attention needs to be given to historical catch reconstruction in Oregon as well, so this area can be included in the next assessment of blue rockfish. A common problem in California and Oregon is the mixing of similar species (i.e. black and blue rockfish) in the commercial fishery catch data, which is difficult to tease apart.

This assessment had limited information to measure stock abundance. The results of this assessment depend on the assumption of constant proportionality between the recreational CPFV CPUE indices and stock abundance.

Reference points

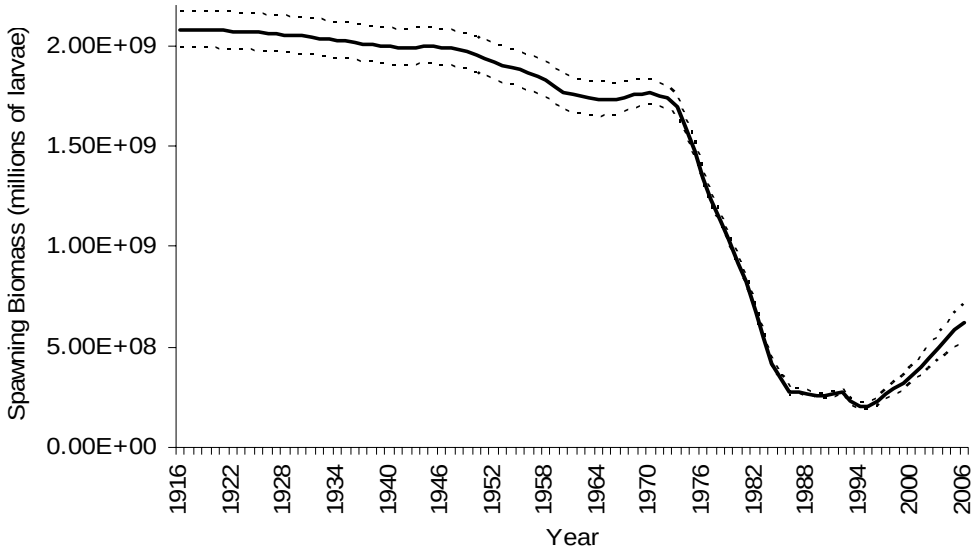
This assessment uses the default target rate of $F_{50\%}$ used for rockfishes on the West coast of the US. Under Pacific Fishery Management Council (PFMC) Groundfish management policy, if the current spawning biomass of the stock falls at or below 25% of the unexploited biomass, the stock is considered overfished. Under the state's guidelines, the stock is considered overfished at or below 30% of the unexploited biomass. Unfished spawning biomass was estimated to be 2077 million larvae in the base model, with the target stock size at 831 million larvae. The base model estimated that the stock could support a maximum sustainable yield (MSY) of 275 metric tons.

	Point Estimate	Uncertainty in estimates
Unfished Spawning Stock Biomass (SB_0) (millions of larvae)	2077	1986-2167
Unfished Summary Age 1+ Biomass (B_0) (mt)	13223	
Unfished Recruitment (R_0) at age 0 (1000s)	3220	3081-3359
Reference points based on SPR proxy for MSY		
Spawning Stock Biomass at SPR (SB_{SPR})(mt)	831	
$SPR_{MSY\text{-}proxy}$	0.5	
Exploitation rate corresponding to $SPR_{MSY\text{-}proxy}$	0.0403	
Yield with $SPR_{MSY\text{-}proxy}$ at SB_{SPR} (mt)	275	

Stock biomass

Blue rockfish were not a highly sought species historically, but an increase in catches in the 1970s resulted in a continuous decline in spawning biomass through the early 1990s. Spawning biomass reached a minimum (10% of unexploited) in 1994 and 1995; however, there has been a constant increase since then. The base model estimated spawning output at 622 million larvae and relative depletion level at 29.7% in 2007.

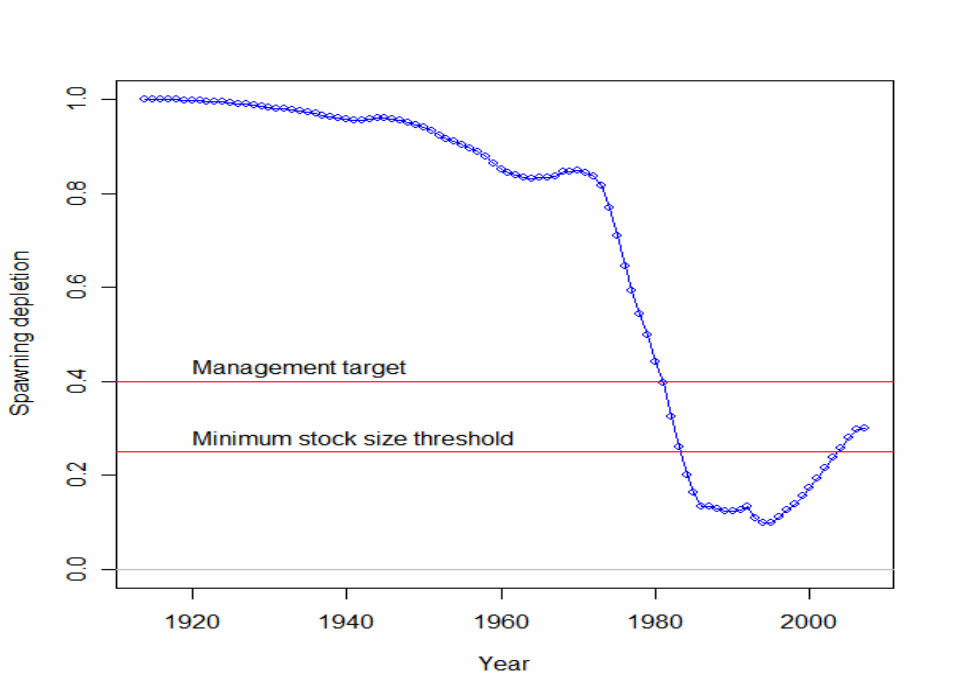
Time series of spawning biomass (~95% CI's) as estimated in the base case model.



Recent trend in estimated blue rockfish spawning biomass (millions of larvae) and depletion

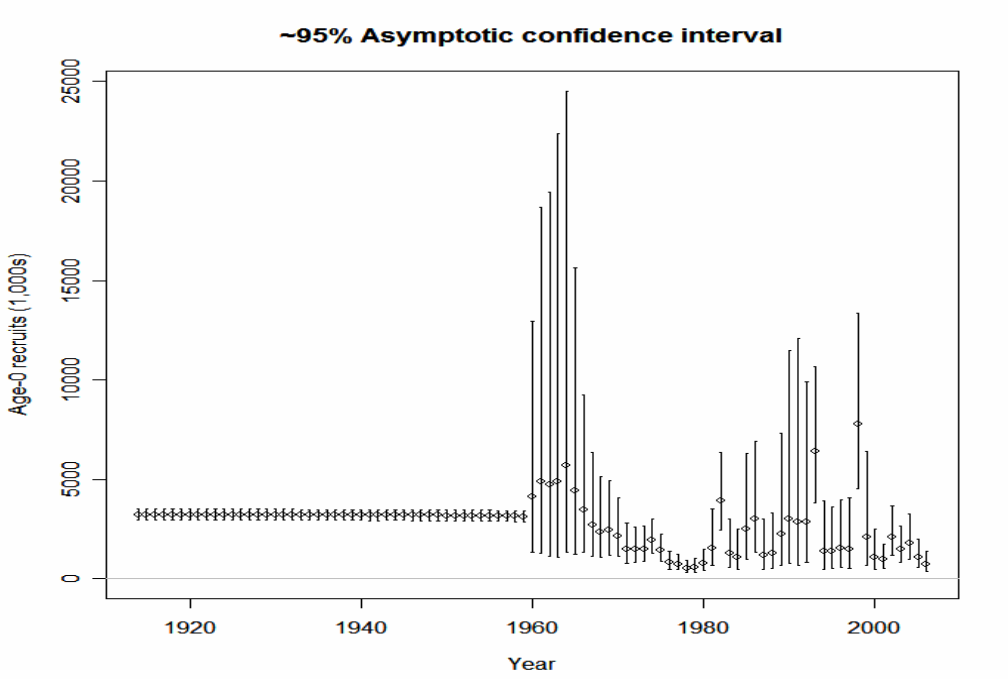
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Spawning Output	289	323	359	401	447	495	537	583	618	622
~95% CI	*259-318*	*286-359*	*317-402*	*352-450*	*391-503*	*431-559*	*464-610*	*501-665*	*528-708*	
Depletion	13.9%	15.5%	17.3%	19.3%	21.5%	23.8%	25.9%	28.1%	29.7%	29.9%

Time series of depletion level as estimated in the base case model.



Recruitment

Recruitment is variable and highly uncertain for blue rockfish. There is little information other than the pre-recruitment index in the recent years to inform the assessment model about recruitments. Recruitment appeared to be high in the 1960s, and more recently strong year classes appeared in 1993 and 1998. With the use of conditional age-at-length data in this assessment, estimated recruitment could potentially be off by a year in capturing the 1999 year class seen in most other groundfish stocks. The late 1970s showed all time low recruitment, with 2006 among the 3 lowest recruitment years estimated.



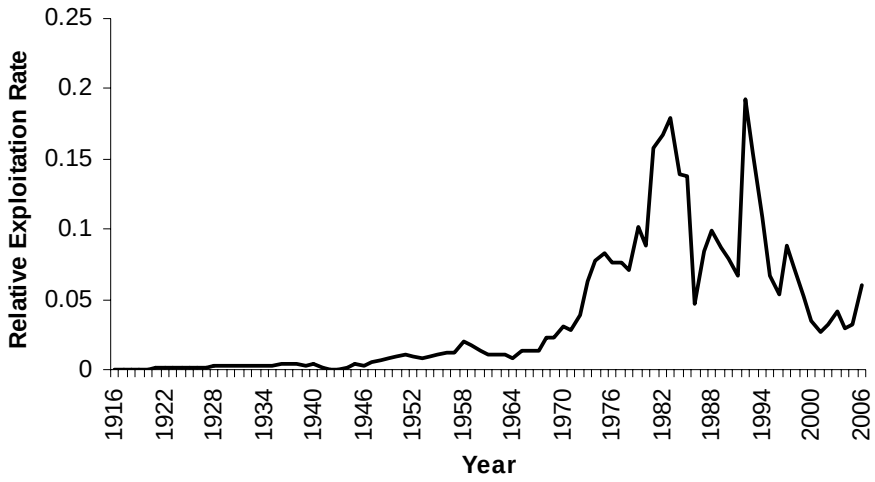
Recent trend in estimated blue rockfish recruitment (1000s)

	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Recruitment	7792	2074	1080	960	2094	1484	1806	1071	735	2261
~95% CI	*5609-9975*	*773-3374*	*592-1567*	*667-1252*	*1490-2698*	*1026-1941*	*1244-2368*	*725-1416*	*496-974*	

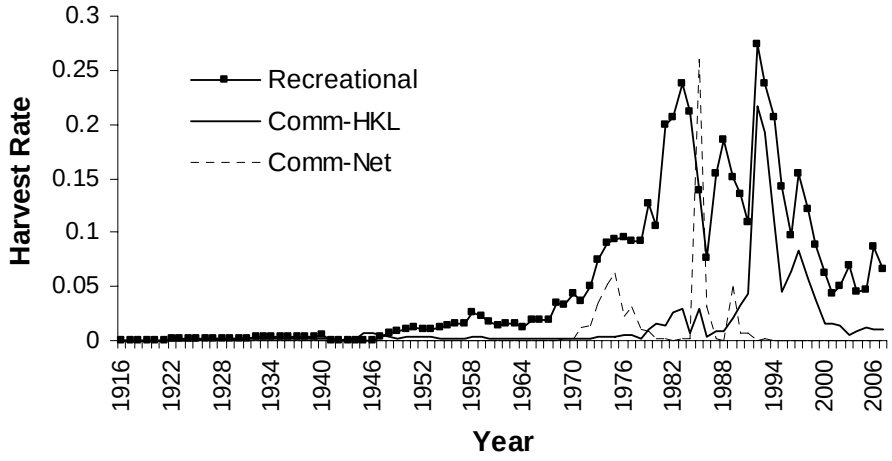
Exploitation status

Blue rockfish harvest was minor in the earlier years, but in the 1970s, recreational harvesting of blue rockfish began to increase with peaks in the early 1980s and early 1990s. The abundance of blue rockfish was at the management target ($SB_{40\%}$) in 1980 and at the overfished threshold in 1982. Fishing mortality exceeded current target levels from the mid 1970s through the late 1990s, but has been close to target levels since 2000.

Time series of estimated relative exploitation rate for the base model.



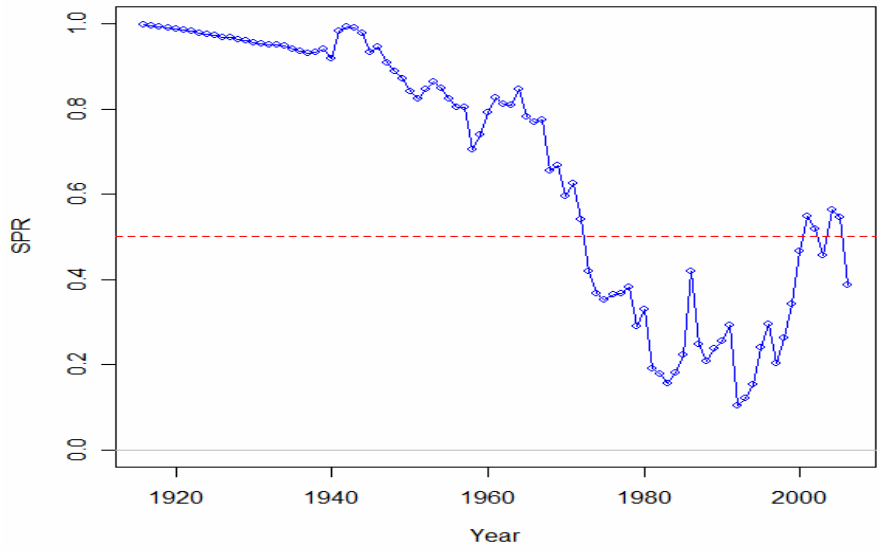
Time series of harvest rates by fishery for the base model.



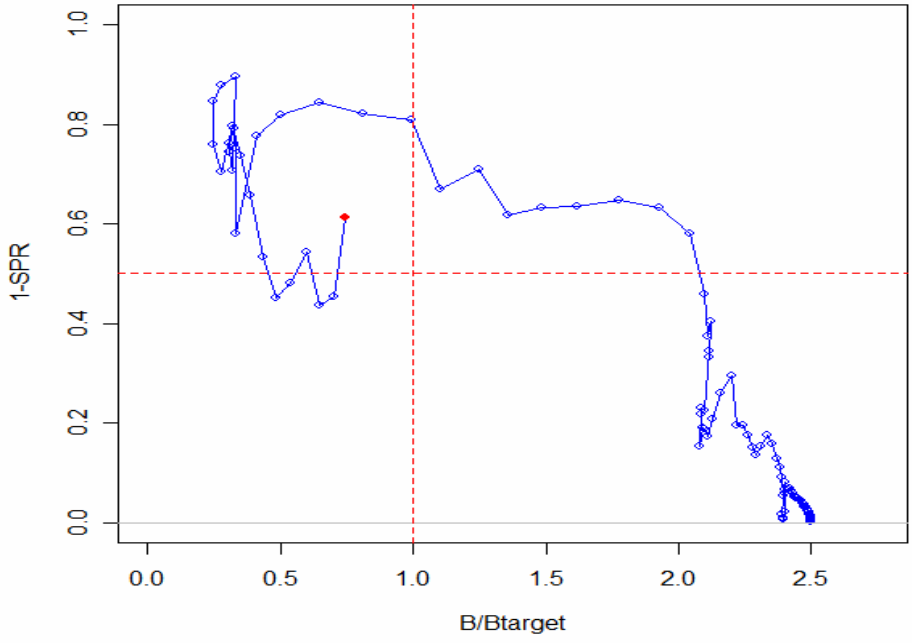
Recent trends in blue rockfish exploitation and harvest rates

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Exploitation	8.8%	7.2%	5.2%	3.4%	2.7%	3.2%	4.2%	3.0%	3.3%	6.0%
(fraction of summary biomass)										
Harvest										
(fraction of available biomass)										
Recreational	15.5%	12.1%	8.9%	6.2%	4.3%	5.1%	6.9%	4.5%	4.6%	8.7%
Comm-HKL	8.3%	5.8%	3.9%	1.5%	1.6%	1.3%	0.6%	0.9%	1.2%	1.1%
Comm-Net	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

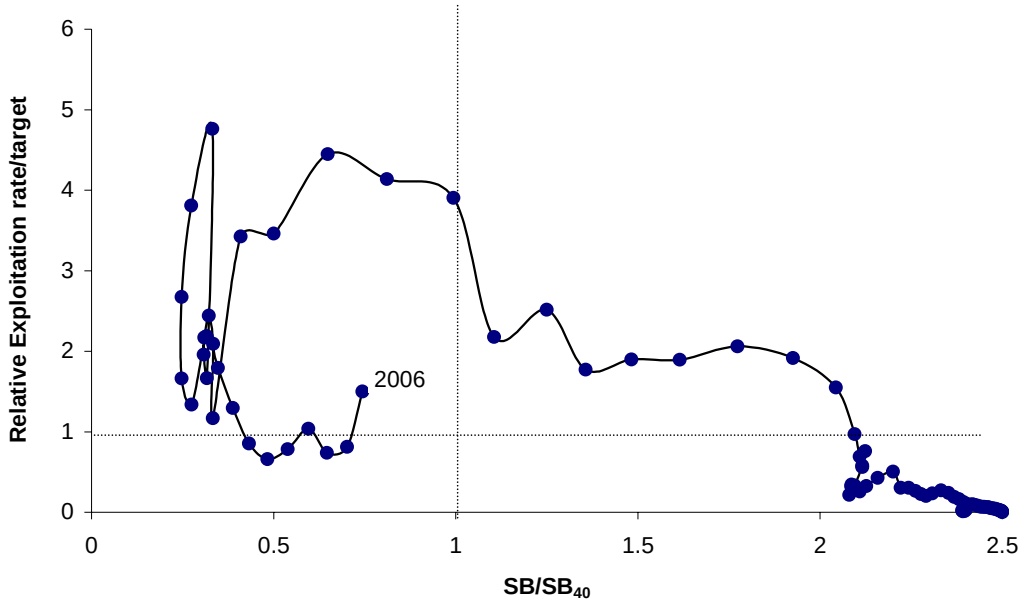
Time series of estimated spawning potential ratio (SPR) for the base case model.



Estimated spawning potential ratio relative to the proxy target of 50% vs. estimated spawning biomass relative to the proxy 40% level from the base case model.



Estimated fishing intensity vs. relative spawning biomass for the base case model. Fishing intensity is the relative exploitation rate divided by the level corresponding to the overfishing proxy (0.40).



Management performance

This is the first assessment of blue rockfish and in the past they have been managed under a "complex." Prior to 2000, this species was managed within the *Sebastes* complex, and since then has been managed under the minor nearshore rockfish complex, north and south of Cape Mendocino (40º10' N. lat.). Blue rockfish have not been considered a "point of concern" for management in the past; hence no ABCs or OYs have been set particularly for this species.

Forecasts

Future catch projections through 2016 were made based on an $F_{50\%}$ fishing rate with 40:10 adjustment. The sum of the average catches from each fishery for the years 2005 and 2006 (263 mtons) were applied to the beginning projection years of 2007 and 2008. The forecast predicts a slight increase in abundance but not enough to support increased harvesting of blue rockfish in the future. According to the base model, blue rockfish may be experiencing overfishing (current F > proxy F_{MSY}), and total catch should be reduced. However, the state of nature corresponding to higher natural mortality (M_{female} = 0.13, M_{male} = 0.15) remains above 40% and allows about 370 mtons to be taken in 2009.

Base model projections for blue rockfish ABC, OY, spawning biomass and depletion

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
ABC (mtons)	*227*	*226*	223	221	219	217	215	215	216	218
OY (mtons)	*263*	*263*	199	198	196	193	192	192	193	195
Spawning Biomass (millions of larvae)	622	628	628	632	631	628	627	628	631	637
Depletion	29.9%	30.3%	30.3%	30.4%	30.4%	30.2%	30.2%	30.2%	30.4%	30.7%

Decision tables

Even though there are many uncertainties in this assessment, the STAR panel and STAT agreed that the decision table could capture some level of uncertainty through alternate scenarios of historical catches and natural mortality (for males and females separately) of blue rockfish. The scenario that suggested a lower level of abundance was with the high catch stream (double BASE) and lower natural mortality ($M_{female} = 0.07$, $M_{male} = 0.09$). The upper level of abundance was bracketed by the low catch stream (1/2 of BASE) and higher natural mortality ($M_{female} = 0.13$, $M_{male} = 0.15$). Even though the STAR and STAT agreed with not assigning probabilities to the states of nature, the –log likelihood values from the model runs for the BASE (1340) and high natural mortality (1338) scenarios suggest they are more likely than the scenario with lower natural mortality (1361).

Since blue rockfish are managed by the State of California under the minor nearshore rockfish complex, a second decision table with the 60:20 adjustment applied is also provided. The state, being more conservative, considers a stock to be overfished at or below 30% of unfished spawning biomass. However, fishing mortality rates have been above both state and federal target levels in recent years, suggesting that overfishing has occurred in the past.

*Decision table (**40:10** adjustment applied) of 10-year projections for alternate states of nature (columns) and management options (rows). Spawning output is in millions of larvae. Base model results are **bolded**. Landings in 2007 and 2008 were based on the sum of the 2005 and 2006 catch averages from the recreational and commercial fisheries.*

			State of nature					
			LOWER bracket (M = 0.07 f, 0.09 m)		Base case (M = 0.1 f, 0.12 m)		HIGHER bracket (M = 0.13 f, 0.15 m)	
			high catch stream		BASE catch stream		low catch stream	
Management decision	Year	Catch (mt)	Depletion	Spawning output	Depletion	Spawning output	Depletion	Spawning output
Low	2007	263	14.4%	418	29.9%	622	49.3%	817
	2008	263	14.3%	415	30.3%	628	49.9%	826
	2009	42	14.0%	407	30.3%	628	50.0%	827
	2010	49	14.7%	429	31.6%	656	51.6%	855
	2011	54	15.4%	447	32.7%	679	52.8%	875
	2012	59	15.9%	464	33.7%	700	53.8%	891
	2013	64	16.5%	480	34.6%	720	54.7%	906
	2014	69	17.1%	497	35.6%	740	55.6%	921
	2015	75	17.7%	515	36.7%	762	56.6%	938
	2016	80	18.3%	533	37.8%	785	57.7%	955
Medium	2007	263	14.4%	418	**29.9%**	**622**	49.3%	817
	2008	263	14.3%	415	**30.3%**	**628**	49.9%	826
	2009	199	14.0%	407	**30.3%**	**628**	50.0%	827
	2010	198	13.9%	404	**30.4%**	**632**	50.2%	831
	2011	196	13.7%	398	**30.4%**	**631**	50.0%	828
	2012	193	13.4%	390	**30.2%**	**628**	49.7%	823
	2013	192	13.2%	384	**30.2%**	**627**	49.4%	818
	2014	192	13.0%	379	**30.2%**	**628**	49.3%	816
	2015	193	12.9%	376	**30.4%**	**631**	49.4%	817
	2016	195	12.9%	375	**30.7%**	**637**	49.6%	820
High	2007	263	14.4%	418	29.9%	622	49.3%	817
	2008	263	14.3%	415	30.3%	628	49.9%	826
	2009	376	14.0%	407	30.3%	628	50.0%	827
	2010	363	12.9%	376	29.1%	604	48.6%	804
	2011	348	11.8%	343	27.8%	577	46.9%	776
	2012	335	10.7%	311	26.5%	550	45.2%	748
	2013	325	9.7%	282	25.4%	527	43.7%	724
	2014	317	8.8%	257	24.5%	509	42.6%	705
	2015	311	8.1%	235	23.8%	495	41.8%	691
	2016	308	7.4%	217	23.4%	485	41.2%	682

*Decision table (**60:20** adjustment applied) of 10-year projections for alternate states of nature (columns) and management options (rows). Spawning output is in millions of larvae. Base model results are **bolded**. Landings in 2007 and 2008 were based on the sum of the 2005 and 2006 catch averages from the recreational and commercial fisheries.*

			State of nature					
			LOWER bracket (M = 0.07 f, 0.09 m)		Base case (M = 0.1 f, 0.12 m)		HIGHER bracket (M = 0.13 f, 0.15 m)	
			high catch stream		BASE catch stream		low catch stream	
Management decision	Year	Catch (mt)	Depletion	Spawning output	Depletion	Spawning output	Depletion	Spawning output
Low	2007	263	14.4%	418	29.9%	622	49.3%	817
	2008	263	14.3%	415	30.3%	628	49.9%	826
	2009	0	14.0%	407	30.3%	628	50.0%	827
	2010	0	15.0%	435	31.9%	663	52.0%	861
	2011	0	15.9%	461	33.4%	694	53.7%	889
	2012	0	16.8%	487	34.8%	723	55.2%	913
	2013	0	17.7%	514	36.2%	753	56.6%	937
	2014	0	18.6%	542	37.7%	784	58.1%	962
	2015	0	19.7%	572	39.3%	816	59.7%	988
	2016	8	20.7%	604	41.0%	851	61.3%	1015
Medium	2007	263	14.4%	418	**29.9%**	**622**	49.3%	817
	2008	263	14.3%	415	**30.3%**	**628**	49.9%	826
	2009	113	14.0%	407	**30.3%**	**628**	50.0%	827
	2010	121	14.3%	417	**31.1%**	**645**	51.0%	844
	2011	125	14.6%	424	**31.6%**	**657**	51.5%	853
	2012	128	14.7%	428	**32.0%**	**665**	51.8%	858
	2013	132	14.9%	433	**32.5%**	**674**	52.1%	863
	2014	136	15.1%	438	**32.9%**	**684**	52.5%	869
	2015	142	15.3%	445	**33.5%**	**696**	53.0%	877
	2016	148	15.5%	452	**34.1%**	**708**	53.5%	885
High	2007	263	14.4%	418	29.9%	622	49.3%	817
	2008	263	14.3%	415	30.3%	628	49.9%	826
	2009	339	14.0%	407	30.3%	628	50.0%	827
	2010	323	13.1%	382	29.4%	610	48.9%	810
	2011	307	12.2%	355	28.4%	589	47.6%	788
	2012	291	11.3%	330	27.4%	569	46.3%	766
	2013	279	10.6%	308	26.6%	552	45.2%	748
	2014	270	9.9%	289	26.0%	541	44.4%	735
	2015	266	9.4%	274	25.7%	533	43.9%	727
	2016	263	9.0%	262	25.5%	530	43.7%	723

Research and data needs

- As with many rockfish, reconstruction of the historical landings is difficult and very time consuming. A standard method should be applied, and historical documentation should be provided to highlight major fishery events to allow more certainty in these estimates.
- Continued genetic studies to confirm that blue rockfish is two species. Some major research that is needed related to this topic include: aging to determine differences in growth and longevity, fecundity, maturation schedules and their spatial distributions.
- More biological sampling, especially age composition information, of the recreational and commercial fisheries to be able to determine changes in life history parameters over time and space.
- Research to help understand the lack of males in the catches. Is this a selectivity issue or a substantial difference in natural mortality between males and females?
- Development of a fishery-independent survey to capture changes in stock abundance. Many assessments have used a recreational CPFV CPUE index to determine this, which is not as reliable considering management changes (i.e. bag limits, closures) that continue to occur.
- Sex-specific length and age information from the recreational fishery. Attempts have been made to gather sex-specific information from sampling the commercial fishery, and even though samples are small, it is informative.
- Environmental factors that affect survival of juvenile blue rockfish need to be explored further. The lack of kelp habitat caused by increasing ocean temperatures (warmer waters) in southern California since the 1990s led the STAT to believe that the lack of blue rockfish in this area was not due to fishing.

Regional Management Concerns

Blue rockfish are going to be a challenge for management. Even though efforts were made to accommodate the changes in growth over time and space, sufficient data were not available to accomplish this within the assessment model. Simulation studies are needed to determine how much affect these spatial and temporal changes have on model results. Also, the exclusion of Oregon and southern California in this assessment adds additional challenges for management. Finally, two species of blue rockfish exist which may have important implications for regional management, particularly not knowing their habitat associations and/or geographic distributions.

The STAT advises that this assessment be used with caution for management purposes. The STAT feels strongly that the decision table does not provide symmetrical bracketing of uncertainty (described in decision table section) and that the BASE and high M scenarios are more likely than the low M scenario. It is recommended that only the projections under the BASE and high M scenarios be considered for management purposes.

Summary Table

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Landings (mt)	297	234	166	135	167	229	165	185	341	341
Estimated Discards (included in total catch)	0	0	0	0	0	0	0	0	0	0
Estimated Total Catch (mt)	297	234	166	135	167	229	165	185	341	341
ABC (mt)										
OY (mt)										
SPR	0.22	0.25	0.36	0.48	0.56	0.53	0.45	0.58	0.56	0.41
Exploitation Rate (total catch/summary biomass)	0.07	0.05	0.03	0.03	0.03	0.04	0.03	0.03	0.06	0.06
Summary Age 1+ Biomass (B) (mt)	4114	4488	4825	5084	5298	5474	5541	5636	5649	5447
Spawning Stock Biomass (*SB*) (millions of larvae)	289	323	359	401	447	495	537	583	618	622
Uncertainty in SB estimate	259-318	286-359	317-402	352-450	391-503	431-559	464-610	501-665	528-708	
Recruitment at age 0 (1000s)	7792	2074	1080	960	2094	1484	1806	1071	735	2261
Uncertainty in Recruitment estimate	5609-9975	773-3374	592-1567	667-1252	1490-2698	1026-1941	1244-2368	725-1416	496-974	
Depletion (SB/SB0)	13.9%	15.5%	17.3%	19.3%	21.5%	23.8%	25.9%	28.1%	29.7%	29.9%
Uncertainty in Depletion estimate	na	na	na	na	na	na	na	na	na	na

Uncertainty estimates based on 95% confidence intervals.